

**TRANSPARENT, COATED, SHRINKABLE, ORIENTED**  
**POLYPROPYLENE FILM**

**BACKGROUND OF INVENTION**

The present invention relates to the field of polymer films and, more  
5 particularly to a coated heat-shrinkable biaxially oriented polypropylene film.

A shrink film's distinguishing characteristic is its ability upon exposure to some level of heat to shrink or, if restrained, to create shrink tension within the film. This ability is activated by the packager when the wrapped product is passed through a hot air or hot water shrink tunnel. The resulting shrinkage of the film  
10 results in an aesthetically pleasing, transparent wrapping which conforms to the contour of the product while providing the usual functions required of packaging materials such as protection of the product from loss of components, pilferage, or damage due to handling and shipment. Typical items wrapped in polyolefin shrink films are compact discs, tapes, perfumes, tobacco products, chocolates,  
15 toys, games, sporting goods, stationery, greeting cards, household products, office supplies and food products.

The manufacture of shrink films requires relatively sophisticated equipment including extrusion lines with "racking" capability, irradiation units when cross-linking is desired, tenter frames, mechanical centerfolders, and slitters.  
20 "Racking" or "tenter framing" are conventional orientation processes which cause the film to be stretched in the cross or transverse direction and in the longitudinal or machine direction. The films are usually heated to their orientation temperature

range which varies with different polymers but is usually above room temperature and below the polymer's melting temperature. After being stretched, the film is rapidly cooled to quench it and freeze the molecules of film in their oriented state. Upon heating, the orientation stresses are relaxed and the film will begin to shrink 5 back to its original, unoriented dimension.

Certain applications for heat-shrinkable films, e.g., printed films or packaging of materials such as boxes present unique problems. Heat-shrinkable films typically have a shrinkability of at least 20% and often more than 40%. When such printed heat-shrinkable films are shrunk, the printing tends to become 10 distorted and unclear. Therefore, these heat-shrinkable films are unsuitable for applications which require printable films. Another problem with heat-shrinkable films that are currently being used is that when the films are used on products that have sharp edges, they tend to puncture and when used to cover light weight boxes, they tend to crush the boxes. Consequently, heat-shrinkable films have not 15 been used for these applications. For more detailed disclosures of heat-shrinkable films, reference may be made to U.S. Pat. Nos. 4,194,039, 3,808,304; 4,188,350; 4,377,616; 4,390,385; 4,448,792; 4,582,752; and 4,963,418, all of which are incorporated herein in their entirety by reference.

It is recognized by those skilled in the art that a coated film is preferred in 20 many packaging applications. However, past attempts to provide a coated film having low shrinkability (e.g., 6% to 12%) have encountered difficulties resulting from the shrinkage of the film during the coating process. In this regard, a typical coated film uses a water based coating which is applied to the film structure and

then dried, usually in a hot air oven. When such a process is used to coat a film having low shrinkability (e.g., 6% to 15%), the drying process shrinks the film to an extent that it is no longer acceptable for use in most packaging applications.

In order to overcome the problems encountered with the heat-shrinkable films that are presently in use, a coated heat-shrinkable film with a low degree of shrinkability is needed. Such films would provide printing that would not distort when the film is shrunk. Moreover, such low shrink films would not have as much force when shrunk and, therefore, would be less likely to be punctured or to crush the products.

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### SUMMARY OF THE INVENTION

In accordance with the present invention, a transparent, coated heat-shrinkable polymeric film is provided having an oriented substrate which includes a polyolefin and has a first shrinkage percentage and a coating disposed on at least one side of the substrate. The shrinkage percentage of the coated film is at least 80% of the first shrinkage percentage, preferably at least 90% and most preferably at least 95%. The oriented substrate of the film includes a blend layer of polypropylene homopolymer and a copolymer of propylene and ethylene. Preferably, the blend layer is about 90 wt. % polypropylene homopolymer and about 10 wt. % propylene and ethylene copolymer. The film can also include a pair of outer layers disposed on either side of the blend layer. The outer layers are preferably a propylene-ethylene-butylene terpolymer.

The shrink during the application on packaging machines is achieved through the balanced MD-TD (machine direction and transverse direction) film retraction in and near the sealed areas.

The coated heat-shrinkable polymeric film of the present invention has

5 water-based coatings, which preferably include acrylates, polyvinylidene chloride, PVOH, EVOH or clay fillers. For example an acrylic coating can be a terpolymer of (a) from about 2.5 to about 6 % by weight of an alpha-beta monoethylenically unsaturated carboxylic acid, preferably selected from the acrylic acid, methacrylic acid or mixtures thereof and (b) from about 97.5 to about 94 % by weight of

10 neutral monomer esters. The neutral monomer esters include methyl acrylate or ethyl acrylate and methyl methacrylate, preferably from about 30% to about 60% by weight methylacrylate and from about 40% to about 70% by weight methyl methacrylate. The coating mixture may also contain inert inorganic fillers and waxy and particulate antiblock materials.. In one embodiment, one surface of the

15 film is coated with a water-based acrylic and the other surface is coated with polyvinylidene chloride.

The substrate of the heat-shrinkable film of the present invention has an overall thickness of from about 12 to about 60 microns. Preferably, the substrate has an overall thickness of from about 18 to about 29 microns and each of the

20 outer layers has a thickness of approximately 0.5 to 1 micron. In order to ensure that the coating adheres to the substrate, the substrate is treated prior to coating by known and conventional methods. A primer may be applied to the substrate after the treatment, preferably a polyethylene imine, an epoxy type, a polyurethane

type. The film has a shrink of between about 6% and about 15% and preferably between about 7% and about 10%.

The present invention also includes a coated heat-shrinkable polymeric film made by a process forming a polypropylene-based substrate, biaxially 5 orienting the substrate to form a heat-shrinkable film having a first shrink percentage, coating the substrate with a water-based coating to form a coated heat-shrinkable polymeric film, and drying the coated film. After the film is dried, the shrink percentage of the coated film is at least 80% of the first shrink percentage, preferably at least 90% and most preferably at least 95%. The substrate is formed 10 as a core layer disposed between two outer layers. The core layer is a blend of polypropylene homopolymer and either a copolymer of propylene-ethylene or propylene-butylene or a propylene-ethylene-butylene terpolymer and the outer layers are a propylene-ethylene-butylene terpolymer. The coating is a water-based coating that includes an acrylate, polyvinylidene chloride, PVOH, EVOH or 15 clay fillers. The substrate can be treated, preferably corona treated, and a primer can be applied to the substrate prior to coating.

The present invention also provides a process for making a coated heat-shrinkable polymeric film which includes forming a polypropylene-based substrate, biaxially orienting the substrate to form a heat-shrinkable film having a 20 first shrink percentage, coating the substrate with a water-based coating to form a coated heat-shrinkable polymeric film, and drying the coated film. After drying, the shrink percentage of the coated film is at least 80% of the first shrink percentage, preferably at least 90% and most preferably at least 95%.

- The substrate is formed as a core layer disposed between two outer layers. The core layer is a blend of polypropylene homopolymer and a copolymer of propylene and ethylene and the outer layers include a propylene-ethylene-butylene terpolymer. The coating is a water-based coating which includes an acrylate, 5 polyvinylidene chloride, PVOH, EVOH, clay filler or combinations thereof. Prior to coating, the substrate may be corona treated and/or a primer may be applied. The drying step may include controlling air flow, temperature profile and tension of the film to simultaneously prevent both shrinkage and wrinkling of the substrate.
- 10 In a preferred embodiment, the coating process includes priming the substrate at a temperature of from about 100°C to about 110°C and at a tension of from about 13 lbs/meter to about 18 lbs/meter. After the coating is applied, the coated film is dried at a temperature of from about 90°C to about 100°C and at a tension of from about 10 lbs/meter to about 15 lbs/meter.

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#### **DETAILED DESCRIPTION OF THE INVENTION**

The present invention is a transparent, coated packaging film which provides improved product presentation and a method for forming such film. In particular, the present invention is a coated shrinkable packaging film having excellent optical properties, printability, coefficient of friction, sealability and gas 20 and aroma barrier properties. The films of the present invention include a substrate which is coated with a water-based coating. The substrate includes a core layer and may also include two outer layers. Intermediate layers, such as adhesive layers, may be disposed between the outer layers and the core layer.

After the substrate is formed, it is biaxially oriented to provide a shrinkability of from about 6% to about 15%. The substrate is coated with a water-based coating which is then dried at a temperature between about 90 °C and about 100 °C to form the coated film. In a preferred embodiment, the substrate is 5 precoated with a water based primer and then dried at a temperature of between about 100° and about 110°C before it is coated. The coated film retains at least 80% of the shrinkability of the uncoated substrate, preferably at least 90% and most preferably 95%.

The different features of the coated heat-shrinkable film of the present 10 invention are described in more detail below.

#### *Core layer*

In a preferred embodiment, the core layer includes a polypropylene homopolymer material which is atactic and which has a melting point, as determined by the DSC (Differential Scanning Calorimetry) method of less than 15 160 °C., e.g., less than 150 °C., or even less than 140 °C. Alternately, the core layer material can include a blend of a more isotactic polypropylene with modifiers which are polyolefin materials which are less crystallizable due to a higher degree of chain imperfections or lower isotacticity.

Modifiers suited to use in the present invention include polyolefins other 20 than isotactic polypropylene. The modifier can be selected from the group consisting of atactic polypropylene, syndiotactic polypropylene, ethylene-propylene copolymer, propylene-butylene copolymer, ethylene-propylene-

butylene terpolymer, polybutylene, linear low density polyethylene and hydrocarbon resins.

In one aspect of the present invention, the modifier, e.g., atactic polypropylene, is added to the core in amounts sufficient to provide a core layer 5 having an overall atacticity greater than 2%, preferably greater than 4%, greater than 5% or greater than 6%, e.g., 6 to 15%. For present purposes, atactic polypropylene has an atacticity of at least 10%, preferably at least 15%, e.g., 15 to 20% or 15 to 25%. Atactic polypropylene can be used alone as the core or added to isotactic polypropylene in amounts such that the resulting mixture comprises 10 to 99 wt % atactic polypropylene, e.g., 10 to 30 wt %, preferably 15 to 20 wt %.  
10 atactic polypropylene. Blends of 15 wt % atactic polypropylene (15% atacticity) and 85 wt % isotactic polypropylene (of 4 to 5% atacticity) are especially preferred. Atactic content can be measured by a polymer's insolubility in boiling n-hexane with chain imperfections being observed via NMR (nuclear magnetic 15 resonance spectroscopy) tests.

A suitable atactic polypropylene for use in the present invention has an atacticity of 15% which can be added to isotactic polypropylene to provide a core mixture containing 15 wt % atactic polypropylene thereby increasing overall core atacticity by 2.25 wt %.

20 Commercially available isotactic propylene suited to use in the present invention includes Fina 3371 from Fina Oil and Chemical Co., Chemical Div., Dallas, Tex. Atactic polypropylenes which are commercially available include L1300 from Novolen of BASF Corp., Parsippany, N.J.

In one embodiment, the preferred propylene homopolymer is a well-known, commercially available polymer obtained by the stereoregular polymerization of propylene based on the use of Ziegler-Natta catalysts. Such catalysts generally are reaction products of an organometallic compound 5 belonging to Groups IA to IIIA with a compound of a transition metal of Groups IVB to VIII. Propylene homopolymers and the preparation thereof are described in greater detail by G. Crespi and L. Luciani in "Olefin Polymers (Polypropylene)," Kirk-Othmer Encyclopedia of Chemical Technology, Third Edition, John Wiley & Sons, New York (1981), Volume 16, pages 453-469, the 10 entire contents of which are incorporated by reference. Particularly preferred are propylene homopolymers having a melting point range of from about 321 °F. to about 336 °F.

In another embodiment, the present invention employs a core layer which includes polypropylene as described above, preferably isotactic polypropylene, 15 mixed with polybutylene modifier to provide a core layer containing 2 to 15 wt % polybutylene, preferably 5 to 10 wt % polybutylene. Suitable polypropylene/polybutylene-1 homogeneous blends are described in U.S. Pat. 3,808,304, the disclosure of which is incorporated by reference herein in its entirety. This disclosure teaches blends containing from 30 to 90 weight parts of 20 polypropylene, and correspondingly, from 70 to 10 weight parts of polybutene-1. Suitable polybutylenes include PB 8430, available from Shell Chemical Co. of Houston, Tex.

In yet another aspect of the invention, the core layer comprises polypropylene as described above, preferably isotactic polypropylene, mixed with ethylene-propylene copolymer modifier, e.g., 2 to 10 wt % ethylene-propylene (E-P) copolymer, preferably 3 to 10 wt % E-P copolymer. Suitable E-P copolymer 5 can contain from 2 to 7 weight percent ethylene, the balance being propylene. The copolymers can have a melt index at 230 °C. generally ranging from 2 to 15, preferably from 3 to 8. The crystalline melting point is usually from about 125 °C. to about 150 °C., and the number average molecular weight is about 25,000-100,000. The density is preferably from 0.89 to 0.92 g/cm<sup>3</sup>. Suitable E-P 10 copolymers include EP 8573, available from Fina Oil and Chemical Co., Chemical Div., Dallas, Tex.

In still another aspect of the invention, the core layer is a blend of polypropylene as described above, preferably isotactic polypropylene, mixed with 0 to 10 wt % ethylene-propylene copolymer, said copolymer preferably being 15 50 to 100 wt % E-P copolymer which contains from 0.5 to 1 wt % ethylene, the balance being propylene. These fractional copolymers are commercially available as ready-mix resin containing 0.6 wt % ethylene (4173 from Fina).

In another aspect of the invention, the core layer is a blend of polypropylene as described above, preferably isotactic polypropylene, mixed with 20 50 propylene-butylene copolymer. The core layer can comprise 5 to 20 wt % propylene-butylene copolymer, preferably 10 to 20 wt %. Suitable propylene-butylene copolymers include Cefor SRD4-105, and Cefor SRD4-104 available

from Shell Chemical Co. The core layer can comprise 5 to 20 wt % of the propylene-butylene copolymer as modifier.

In yet another aspect of the invention, the core layer is a blend of polypropylene as described above, preferably isotactic polypropylene, mixed with 5 linear low density polyethylene (LLDPE). These polymers typically have a melt index of 1 to 10. The linear low density polyethylenes should have a density in the range 0.88-0.94 g/cc, preferably, 0.89-0.92 g/cc. The linear low density polyethylenes may be derived from ethylene together with other higher comonomers such as butene-1, hexene-1 or octene-1. The core layer can comprise 10 2 to 15 wt % LLDPE, preferably 5 to 10 wt % LLDPE. Commercially available LLDPE's include Exact 2009, Exact 2010, and Exact 3016 available from Exxon Chemical Co.

In a particularly preferred embodiment, the core layer is a blend of polypropylene as described above, preferably isotactic polypropylene, mixed with 15 syndiotactic polypropylene and, optionally, ethylene-propylene copolymer. Syndiotactic polypropylene can be present in the core layer in amounts ranging from 2 to 20 wt %, say, 4 to 12 wt %, preferably 4 to 8 wt %, with 0 to 40 wt % ethylene-propylene copolymer, preferably 0 to 20 wt % E-P copolymer. Suitable E-P copolymers are described above. The presence of E-P copolymer improves 20 MD tensile strength in the secondary orientation step. However, E-P copolymer content must be carefully determined inasmuch as the presence of E-P copolymer can cause undesirable film elongation even at lower temperatures, e.g., 60 °C.

(140 °F.) drying temperatures, which elongation can cause registration problems during converting processes such as printing.

The syndiotactic polypropylene used as a modifier in the present invention can possess an isotacticity of less than 15%, in particular less than 6%. The 5 weight average is preferably between about 60,000 and about 250,000, in particular between about 90,000 and about 160,000. The mean molar masses can be determined according to customary methods; of these, the method of gel permeation chromatography has proven to be particularly suitable. Commercially available syndiotactic polypropylene resins suited to use in the present invention 10 include EOD 9306 and EOD 9502 available from Fina.

In yet another aspect of the invention, the core layer is a blend of polypropylene as described above, preferably isotactic polypropylene, mixed with ethylene-propylene-butylene terpolymer as modifier. The core layer can comprise 5 to 20 wt % of the terpolymer. Suitable terpolymers include those containing 3 15 to 5 wt % ethylene and 6 to 10 wt % butylene. Other suitable ethylene-propylene-butylene terpolymers include those containing 0.5 to 3 wt % ethylene, and 13 to 20 wt % butylene. Suitable core layers of the present invention can comprise recycled polypropylene (RPP), e.g., up to 25 wt % RPP, preferably up to 15 wt % RPP.

20 The core layer of the present invention may also comprise a plurality of voids formed by cavitation about a solid cavitation agent. Polybutylene terephthalate, e.g., in amounts comprising 4 to 8 wt % of the core layer, well-dispersed as fine spherical particles, e.g., 0.2 to 2 microns in diameter, as

- described in U.S. Pat. Nos. 5,288,548; 5,267,277; and 4,632,869, all of which are incorporated herein by reference, is a suitable cavitation agent. The spherical particles form microvoids on orientation, resulting in a white opaque product.
- Such a core layer can further comprise a supporting layer of polypropylene on one or both sides of the core with at least one of said layers containing 4 to 15 wt % TiO<sub>2</sub>. Further description of such use of TiO<sub>2</sub>-containing layers is found in U.S. Pat. No. 5,091,236, the contents of which are incorporated herein by reference. Incorporation of skin layers over the supporting layers serves to encapsulate the abrasive TiO<sub>2</sub> and provides a highly opaque structure.
- 10        The opacity and low light transmission of the film may be enhanced by the addition to the core layer of from about 1% by weight and up to about 10% by weight of opacifying compounds, which are added to the melt mixture of the core layer before extrusion. Opacifying compounds which may be used include iron oxides, carbon black, graphite, aluminum, TiO<sub>2</sub>, and talc.
- 15        The aforementioned blends of propylene and other constituents noted above may be admixed by any suitable means to form a homogeneous blend, such as dry mixing, solution mixing, or mixing the two polymers together while in a molten state or combinations thereof.

#### *Outer Layer*

- 20        The outer layer of the present invention may be any of the coextrudable, biaxially orientable heat-shrinkable film-forming resins known in the prior art. Such materials include those discussed above which are suited to use in the core layer, including isotactic polypropylene, atactic polypropylene, polypropylene

blended with polybutylene, propylene-butylene copolymer, and ethylene-propylene copolymer, including fractional E-P copolymer. In addition, polyethylene or ethylene-propylene-butylene terpolymer may be employed as the outer layer.

5       In one embodiment of the present invention, the ethylene-propylene-butylene random terpolymers suited to use in the outer layers include those containing 1-5 weight percent random ethylene, 10-25 weight percent random butylene. The amounts of the random ethylene and butylene components in these copolymers are typically in the range of 10 to 25 percent total (ethylene plus  
10      butylene). Typical terpolymers of this type include those with about 1-5 percent ethylene and 10-25 percent butylene. These copolymers typically have a melt flow rate in the range of about 5 to 10 with a density of about 0.9 and a melting point in the range of about 115°C to about 130°C.

In another embodiment of the present invention, the outer layers of the  
15     substrate are propylene-ethylene-butylene (P/E/B) terpolymers which preferably contain at least about 80% propylene. Preferably, the P/E/B terpolymer contains from about 2% to about 7% ethylene, more preferably about 3% ethylene, and contains from about 2% to about 7% butylene, more preferably about 4% butylene, with the balance being propylene. An exemplary commercially  
20     available propylene terpolymer is the propylene-ethylene-butylene terpolymer #7510 (93% propylene, 3% ethylene, and 4% butylene), from Chisso Corp., Tokyo, Japan. The P/E/B terpolymer materials have also been found to impart

beneficial improvements in optical properties, including increased gloss and reduced haze.

In one aspect of the invention the outer layer is derived from a linear low density polyethylene (LLDPE). These polymers typically have a melt index of 1 to 10. The linear low density polyethylenes may have a density as high as 0.94, usually in the range 0.90-0.91, with a melt index from about 1 to about 10. The linear low density polyethylenes may be derived from ethylene together with other higher comonomers such as butene-1, hexene-1 or octene-1.

Each outer layer can range in thickness from 0.5 to 3 microns (0.02 to 0.12 mil), preferably 0.5 to 1.0 micron (0.02 to 0.04 mil).

In certain embodiments of the present invention, only one surface of the substrate is coated. In such cases, prior to incorporation in the film, e.g., before extrusion, at least one of the outer layers can be compounded with an anti-blocking effective amount of an anti-blocking agent, e.g., silica, clays, talc, glass, and the like which are preferably provided in the form of approximately spheroidal particles. The major proportion of these particles, for example, anywhere from more than half to as high as 90 weight percent or more, will be of such a size that significant portion of their surface area, for example, from about 10 to 70 percent thereof, will extend beyond the exposed surface of the outer layer. In a preferred embodiment, the anti-blocking agent comprises non-meltable silicone resin, e.g., particulate cross-linked hydrocarbyl-substituted polysiloxanes. Particularly preferred particulate cross-linked hydrocarbyl-substituted polysiloxanes include the polymonoalkylsiloxanes. Most preferred are non-

meltable polymonoalkylsiloxanes characterized as having a mean particle size of 0.5 to 20.0 microns and a three dimensional structure of siloxane linkages. Such materials are available from Toshiba Silicone Co., Ltd., worldwide, and in the United States from General Electric Co., and are marketed under the tradename 5 Tospearl. Other commercial sources of similar suitable materials are also known to exist. Such materials are further described as non-meltable crosslinked organosiloxane resin powders in U.S. Pat. No. 4,769,418, incorporated herein by reference. Effective amounts of the particulate cross-linked hydrocarbyl-substituted polysiloxane anti-blocking agent can range from 100 to 5000 ppm, 10 preferably 1000 to 3000 ppm, e.g., from 2500 to 3000 ppm, based on loading of the resin from which the outer layer is prepared.

Reduced coefficient of friction (COF) and reduced antistatic characteristics at the surface of the outer layer or layers can be achieved in accordance with the disclosure set out in U.S. Pat. No. 5,264,277, incorporated herein by reference, 15 which discloses the use of migratory slip agents and antistatic agents in multilayer films. Reduced COF may also be obtained by treating one or both outers with 2000 to 15000 ppm silicone oil.

If desired, the exposed surface of the outer layer or outer layers can be treated in a known and conventional manner, e.g., by corona discharge to improve 20 its receptivity to printing inks, coatings, adhesive anchorage, and/or its suitability for such subsequent manufacturing operations as lamination.

It is preferred that all layers of the substrate of the present invention be coextruded, after which the substrate can be biaxially. Coextrusion can be carried out in a multilayer melt form through a flat die.

*Coating*

5 In general, the uncoated substrate films employed in the practice of the present invention are usually from about 12 microns to about 60 microns in thickness and preferably from about 18 microns to about 29 microns.

Before applying the coating composition to the appropriate substrate, the surface of the substrate film is treated to ensure that the coating will be strongly adherent to the film thereby eliminating the possibility of the coating peeling or being stripped from the film. This treatment may be accomplished by employing known prior art techniques such as, for example, film chlorination, i.e. exposure of the film to gaseous chlorine, treatment with oxidizing agents such as chromic acid, plasma, hot air or steam treatment, flame treatment and the like. Although any of these techniques may be effectively employed to pretreat the film surface, a particularly desirable method of treatment has been found to be the so-called electronic treatment method which comprises exposing the film surface to a high voltage corona discharge while passing the film between a pair of spaced electrodes. After electronic treatment of the substrate film surface, it may be coated with the coating composition of the present invention which coating will then exhibit a tendency to more strongly adhere to the treated film surface.

In applications where even greater coating-to-film adherence is desired, i.e. greater than that resulting from treatment of the film surface by any of the

aforediscussed methods, an intermediate primer coating may be employed to increase the adherence of the coating composition of the present invention to the substrate film. In that case, the film is first treated by one of the foregoing methods, electronic treatment being a preferred method to provide increased active adhesive sites thereon (thereby promoting primer adhesion) and to the thus treated film surface there is subsequently applied a continuous coating of a primer material. Such primer materials are well known in the prior art and include either water based or solvent based poly (ethylene imine), epoxy and polyurethane. A particularly effective primer coating for purposes of the present invention has been found to be poly (ethylene imine). The imine primer provides an overall adhesively active surface for thorough and secure bonding with the subsequently applied coating composition of this invention. The primer is applied to the electronically treated base film by conventional solution coating means such as offset rollers application. It has been found that an effective coating solution concentration of the poly (ethylene imine) applied from either aqueous or organic solvent media such as ethanol, for example, in a solution comprising about 0.5% by weight of the poly (ethylene imine).

*Process for Making the Coated Heat-Shrinkable Film*

The coated heat-shrinkable polymeric film of the present invention is made by first forming a biaxially oriented heat-shrinkable polyolefin substrate. After extrusion of the substrate utilizing conventional film-making techniques, the 5 substrate is heated and molecularly oriented by stretching it in both the longitudinal direction and the transverse direction. The oriented substrate has a shrinkage of less than 15%, preferably between 6% and 13% and a first shrinkage percentage as determined by the test described in Example 1. The substrate is then coated on at least one side with a water based coating and dried in an oven 10 under controlled temperature and tension conditions to form a coated film. The coating is applied at a coating weight of about 0.5 to about 1.2 g/m<sup>2</sup>.

In some embodiments, the substrate is pretreated prior to coating on at least one side in order to improve the adherence of the coating. The substrate is preferably pretreated by corona treatment to at least 40 dynes/cm. The substrate 15 may also be treated on at least one side by applying a primer which makes the surface more receptive to the coating. Preferably, the primer includes polyethylene imine, epoxy type or polyurethane type. The primer is applied at a coating weight of from about 0.02 to about 0.08 g/m<sup>2</sup>. The precoated substrate is dried in an oven at a temperature of from about 90°C to about 120°C, preferably 20 from about 100°C to about 110°C and at a tension of from about 10 lbs/meter to about 22 lbs/meter, preferably from about 13 lbs/meter to about 18 lbs/meter. The precoating process is carried out at a coating speed of between 300 and 600 m/min, preferably between 400 and 500 m/min.

The primed substrate is coated on at least one side with a water based coating and passed through at least one topcoat oven. In some embodiments, the substrate is coated on both sides and more than one coating station is used. In the ovens, the temperature and tension are maintained under controlled conditions so

5 that shrinkage of the film is minimal. The substrate is dried at a temperature of from about 80°C to about 110°C, preferably from about 90°C to about 100°C and at a tension of from about 7 lbs/meter to about 18 lbs/meter, preferably from about 10 lbs/meter to about 15 lbs/meter. The coating process is carried out at a coating speed of between 300 and 600 m/min, preferably between 400 and 500 m/min.

10 The drying step includes controlling air flow, temperature profile and tension of the film to simultaneously prevent both shrinkage and wrinkling of the substrate. The conditions in the precoat oven and the topcoat ovens are shown in Table 1.

The coating can include an acrylate, polyvinylidene chloride, PVOH, EVOH or a clay filler. A preferred coating includes a terpolymer of from 2.5% to

15 about 6 % by weight of an alpha-beta monoethylenically unsaturated carboxylic acid from the group consisting of acrylic acid, methacrylic acid and mixtures thereof; and from 94% to about 97.5% by weight of neutral monomer esters. The neutral monomer esters include from about 40% to about 70% by weight of methyl methacrylate or ethyl acrylate and from about 30% to about 60% by

20 weight of methylacrylate. The coating can also include an inert inorganic filler.

**Table 1**  
Operating Conditions For Precoat Oven And Topcoat Ovens

Parameter	Precoat Oven	Topcoat Ovens
Temperature	100°-110°C	90°-100°C
Tension	13 - 18 lbs/meter	10 - 15 lbs/meter

The coated heat-shrinkable films of the present invention have a shrinkage of between 6% and 15%, preferably between about 7% and 10% and a balanced  
5 MD - TD shrink of between 6% and 13%. The shrinkage percentage of the coated films of the present invention is at least 80% of the first shrinkage percentage of the uncoated substrate preferably 90% and most preferably 95%. It will be appreciated that the relatively low degree of shrinkage in the coated heat-shrinkable film of the present invention reduces the amount of shrink force in such  
10 film. This allows the films of the present invention to be used to package articles that would puncture a film with a higher degree of shrinkage. This also allows the films of the present invention to be used to package soft articles and soft boxes that would be crushed by a film with a high shrink force.

If a heat seal layer is desired, the layer can be made from any of the  
15 conventional materials used for this purpose in conjunction with polyolefin, particularly polyethylene, films. For example, ethylene-vinyl acetate copolymers or ethylene-methacrylic acid salt ionomers can be used (e.g., SURLYN from Dupont). Ethylene-methacrylic acid salt ionomers have been found to be particularly useful in preparing heat-sealable films suitable for use in packaging

foods in bag-in-box operations conducted on vertical, form, fill and seal (VFFS) machinery. U.S. Pat. Nos. 4,343,852, 4,400,428, 4,419,411, 4,502,263, 4,692,379, and 4,734,317, all of which are incorporated herein by reference, disclose films having a base layer of polypropylene polymers and sealable skin layers on one or more sides of the base layer. The heat seal layer can include the heat seal resin alone or with small amounts of other materials. For example, the relatively costly SURLYN ionomer can be mixed with small amounts of less costly materials such as low density polyethylene.

The films of the present invention can be treated to improve their wettability or adhesion to inks and other coatings. Such treatments are conventional and known in the art, for example, exposing the film to corona discharge, flame treating, and the like.

## EXAMPLES

The example set forth below serves to provide further appreciation of the invention but are not meant in any way to restrict the scope of the invention.

### Example 1

For this example, a coated heat-shrinkable film was prepared by forming a substrate from a core layer of 90% homopolymer polypropylene and 10% propylene-ethylene copolymer and outer layers of propylene-ethylene-butylene terpolymer. The overall thickness of the substrate was 23 microns and each of the outer layers were 0.6 microns in thickness. A portion of the substrate was cut into strips and the shrinkage was measured as described below. The haze, gloss and coefficient of friction was also measured. The haze was measured by ASTM D

1003 and the gloss was measured by ASTM D-2457. The coefficient of friction was measured by ASTM D 1894-e. The results are shown in Tables 2 and 3.

Another portion of the substrate was coated. During the coating process, the substrate was first corona treated on both sides and then precoated with 5 polyethylene imine primer on both sides. The precoated substrate was dried in an oven at 105°C and at a tension of 16 lbs/meter to form a primed film. The primed film was then coated on both sides in two steps (using two topcoating stations) with a heat sealable acrylic terpolymer coating having a total monomers weight distribution of 4% methacrylic acid, 54% methylmethacrylate and 42% 10 methylacrylate. In addition, colloidal silica, a carnauba wax as antiblock and talc to provide slip properties were added to the coating in amounts of 38%, 5 % and 0.3 %, respectively, of the acrylic terpolymer weight.

The coated film was dried in an oven after each coating operation at 95°C and at a tension of 15 lbs/meter and a coating speed of 460 m/min. After the last 15 drying operation, the coated films were tested. The shrinkage was measured on 150 mm x 25 mm film strips cut in MD (machine direction) and TD (transverse direction). MD and TD correspond to the length of the sample. The film strips were placed in a ventilated oven set at 135°C for seven minutes. The shrinkage was measured by calculating the ratio between the sample length after the test and 20 the initial length (150 mm). The results are expressed in % and are shown in Table 2. The coated film was also tested for haze, gloss and coefficient of friction and the results are shown in Table 3.

**Table 2**  
Comparison Of Shrinkage For Films Before And After Coating

Direction of Shrink	Percent Shrinkage Before Coating	Percent Shrinkage After Coating	Percent Shrinkage Retained After Coating
MD	-6.3	-6.1	96.8%
TD	-8.5	-8.5	100%

**Table 3**  
Haze, Gloss And Coefficient Of Friction For A 25 $\mu$  Coated Film

Characteristic	Before coating	After coating
Haze %	1.5	1.4
Gloss	86	87
Coefficient of Friction (COF)	0.75	0.25

5        These test results show that the heat-shrinkable films retain most of their shrinkability after the coating step and the characteristics of the coated film, especially haze and gloss, are not significantly affected. The decreased coefficient of friction is due to the inherent properties of the acrylic coating.

**Example 2**

10      The coated, heat-shrinkable film made in Example 1 was used to package a cigar tin box. The cigar tin was wrapped in the film using a conventional packaging machine with a heat sealer. The cigar tin packaged in the coated, heat-shrinkable film of the present invention was then compared to a cigar tin which had packaged in the same manner with a film having an acrylic coating on both

sides and an average balanced MD / TD shrinkage of 5%. As a result of the film retraction in and near the heat sealed areas, the cigar tin packaged with the coated, heat-shrinkable film of the present invention conformed more closely to the shape of the cigar tin and demonstrated an enhanced pack appearance.

5        Thus, while there have been described the preferred embodiments of the present invention, those skilled in the art will realize that other embodiments can be made without departing from the spirit of the invention, and it is intended to include all such further modifications and changes as come within the true scope of the claims set forth herein.

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